Figure 2H (Feb. 23, noon).—Shows much the same distribution of precipitation as the preceding one, except that showers have temporarily ceased in southern Georgia. The whole system is advancing slowly eastward.

Figure 2I (Feb. 23, 4 p. m.).—Shows clearly the difference in the position of the warm-front rain and the two areas of cold-front showers; these areas are separate and distinct.

Figure 2J (Feb. 23, 8 p. m.).—Shows the same general conditions as the preceding figure, except that the whole system has advanced slowly eastward.

This study serves to give an insight into the several types of rainfall associated with the polar front theory, which, in this case, shows a quite orderly behavior. It should be remembered, however, that these LOWS showed remarkably small changes at the centers, the lowest pressure varying between 29.48 and 29.58 inches, not considering the diurnal variation. Further, they had a regularity of movement both with respect to direction and rate that is not usually encountered. The major currents associated with them were uniform and well established. Under such circumstances, forecasting is is not the trying task it sometimes is.

In cases where the movement is rapid, where the barometric changes at the center are marked, or where there is irregularity of direction and rate of movement, well-ordered rain areas are not the rule, and in such cases we have, of necessity, to depend on our ability to forecast the erratic behavior of the LOWS.

The Bjerknes system is used exclusively in Norway and to a considerable extent in the British Isles and other European countries. Since this system has proved so useful in Europe, it behooves us in the United States to study its newer features carefully in order that we may not overlook an opportunity of improving in any way our forecasting methods. Our problem is somewhat different from that of the European meteorologists, as shown by the following statement in the paper of J. Bjerknes and H. Solberg: "Life Cycle of Cyclones and the Polar Front Theory":

> A very large percentage of European cyclones are occluded ones, being dying remainders of previously strong Atlantic depressions. The predominance of occluded cyclones in Europe has led to the statistical result that cyclones usually have a cold core.

In the United States about 40 per cent of all disturbances that affect us develop within the continental confines or along the Atlantic or Gulf coasts. They are, therefore, new or increasing disturbances as distinguished from the dying or occluded cyclones of Europe. On this account it would seem that in this country we must continue to rely in the main on our established methods, with such improvement as can be made on them.

METEOROLOGICAL ASPECTS OF THE SAN FRANCISCO-HAWAII AIRPLANE FLIGHT

By THOMAS R. REED

[Weather Bureau, San Francisco, Calif., September 28, 1926.]

The nonstop flight essayed by naval airplanes from San Francisco to the Hawaiian Islands, August 31 to September 1, 1925, attracted nation-wide attention as being the longest nonstop ocean flight that had yet been attempted. Almost as interesting as the fact of the flight itself are some of the details of organization by which it was hoped to insure the success of the project. None of these details was more important than the meteorological preparations. The plans in this regard were thorough in the extreme. It was recognized from the outset that success would largely hinge on the character of weather encountered, particular dependence being placed on the prevalence of trade winds which normally are found over the greater part of the course between the southern California coast and Honolulu. The extent, duration, and force of these winds therefore constituted the first problem to be considered, since they were to decide the date of departure and the point on the California coast from which the flight would start.

The choice of sites for the commencement of the flight lay between San Francisco and San Diego, the former being finally decided upon in conference between Commander John Rodgers and Lieut. Allen T. Snody and the local officials of the Weather Bureau in San Francisco. San Diego, although farther from Hawaii in actual distance than San Francisco, nevertheless had a strong claim. Being some 5° nearer the Equator, San Diego is situated in the latitude of the summer trade winds, and while these winds are not found in the proximity of the southern California coast, it was believed that the trade-wind belt would be sooner entered if the departure were made from the southern city. Furthermore, the winds which would intervene between the coast and the point at sea where the favoring trades were looked for were known to be normally more adverse off the northern California coast than off the southern (see fig. 1). Their direction in both sectors would have a deflecting effect on the planes, but because of their greater strength in the North this effect was likely to be more consequential there than in the South, and might conceivably reach objectionable proportions if the west-east component happened to predominate. The north-south component of these winds caused no apprehension, as any drift arising therefrom would be a help in bringing the planes into the southern latitudes occupied by the northeast trades.

But whatever disadvantages were to be feared from possible west-east components of movement off the north and central coast were more than offset by the counterclaims of shorter mileage from San Francisco and the reasonable certainty of favorable local conditions for taking off. Due to the great fuel load, it was considered desirable that the planes should take off against a wind of at least 15 miles per hour. Another requisite was an adequate stretch of shallow water; the planes must have ample space in which to gain flying speed, and launching has been found to be most readily effected in very shallow water. Ideal conditions in these respects exist along the western shores of San Pablo Bay (as the northern reaches of San Francisco Bay are known), and this site was finally decided upon as the point of departure. Satisfactory test flights under full load were made there before the day of departure. On the final day both planes got off easily and within a few minutes of each other.

The next question to be considered was the date on which the flight should be attempted. Pressure was exerted to have it coincide with the opening of the Diamond Jubilee festival to be held in San Francisco beginning on September 5. Examination of data, however, led to the conviction that the most favorable winds, both locally and in the trade-wind belt would be found

in August. The first attempt did not actually take place, however, until August 31, as it proved impracticable to put the machines in mechanical trim for the flight before that date, and then only the two planes of the *PN-9* type were ready. The *PB-1* plane was found to require still further adjustments and therefore remained behind.

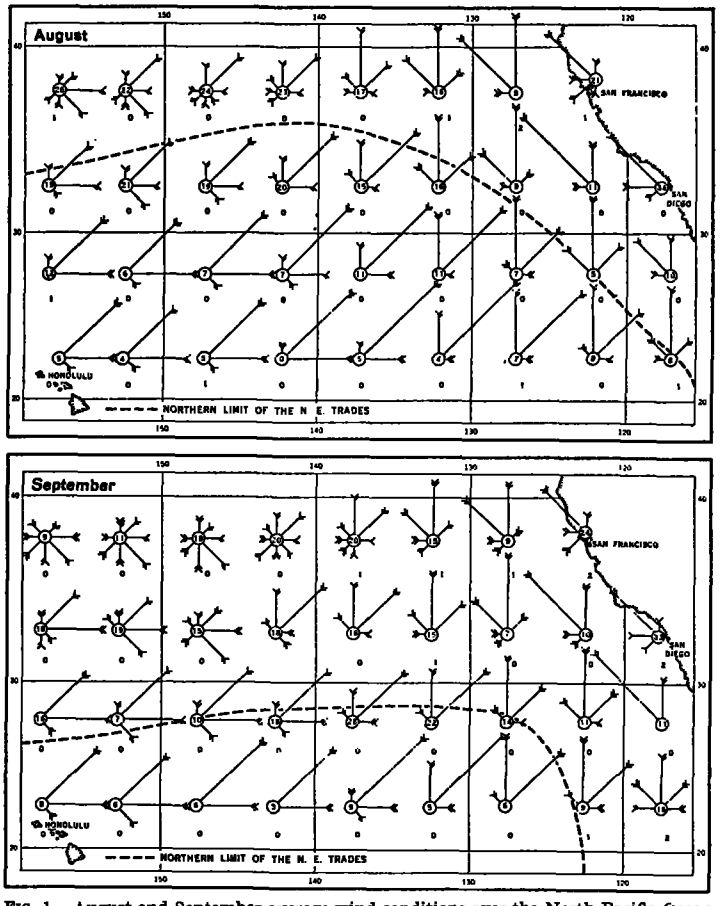

FIG. 1.—August and September average wind conditions over the North Pacific Ocean between the California coast and the Hawaiian Islands. (From the Pilot Charts of the United States Hydrographic Office)

Plans were initiated early in the summer looking toward the issuance of special weather forecasts and bulletins. The following quotations from a letter from the aerological officer on the U. S. S. *Langley* indicate the character of cooperation which was expected of the Weather Bureau, and outline with admirable clarity the organization which the Navy was undertaking to provide for the furtherance of the meteorological program:

The general aerological plan is as follows: There will be ships stationed about every 200 miles from either San Diego or San Francisco (depending upon which place the flight starts, which is to be decided later) to Hawaii. There will be a competent aerological detail on the vessel stationed 600 miles from San Diego or San Francisco; one on the *Langley*, stationed 1,200 miles from San Diego or San Francisco; and one on the *Aroostook*, stationed 1,800 miles from San Diego or San Francisco.

At the base station (San Diego or San Francisco) there will be an aerological unit in charge of Lieutenant Wyatt, which unit will maintain a weather map and issue all aerological information upon which the flight will be based.

The naval air station, Pearl Harbor, Hawaii, and the *Langley*, *Aroostook*, and ship stationed 600 miles from the base station will obtain the following data at 9:15 a. m. and 7:30 p. m. (one hundred and twentieth meridian time) and transmit same promptly to commander flight project at NPL or NPG[1]:

1. Time of observation (one hundred and twentieth meridian time).
2. Barometer.
3. Pressure change preceding two hours, if 0.10 inch or more.
4. Wind velocity and direction at surface and from soundings aloft.
5. Condition of sea.
6. Clouds and their direction.
7. Fog and its direction.
8. Local conditions "are" or "are not" favorable for flight.

After start of flight all aerological reports will be discontinued unless local conditions become or tend to become unsuitable for flying, in which event a brief dispatch will be sent to commander flight project and to station ships nearest the planes for relay to them.

These data will be forwarded by Pearl Harbor, beginning August 26, 1925, and by designated ships after taking assigned stations midnight August 27–28.

The base aerological unit (commander flight project) will use these data for correcting weather maps.

These stations have been directed to send to Weather Bureau, San Francisco, the routine weather reports required from vessels at sea, namely, reports at 7 a. m. and 7 p. m., seventy-fifth meridian time, or 4 a. m. and 4 p. m., one hundred and twentieth meridian time.

We would appreciate it if you would transmit to base aerological unit via NPG a special forecast covering the area between starting point and Honolulu. This information is desired from August 26 until the completion of the flight.

Will you please take up this matter of ships' reports with the various steamship companies and request that they have as many vessels as possible make all regular reports from August 26 until completion of the flight so that you can have as much data as possible in making your forecast? Let me know if there is anything we can do along that line to help.

Do you want all our ships to send the routine reports in addition to the three ships having aerological units on board? I think it will be best to do so.

It is requested that you send commander flight project via NPG all available a. m. and p. m. ship reports.

You can communicate with the commander aircraft squadrons and later with commander flight project at any time at no cost to the Weather Bureau through the commandant twelfth naval district.

Any assistance you can render to the base unit will be appreciated.

The program thus set forth was carried out without material change. Although nearly all steamships plying trans-Pacific routes, with the exception of the Japanese, were already cooperating with the Weather Bureau by rendering daily radiographic weather reports, the urgency of such reports for the period of the flight was emphasized by the broadcast of special notices from radio station NPG, asking for the fullest cooperation in the dispatch of such messages during that time. The response was cordial, and enough data were collected to construct quite complete weather charts of the northeastern Pacific Ocean on the critical days (see fig. 2).

The problem of liaison between the Weather Bureau and the flight-project officers was next considered. Choice of several locations for the establishment of meteorological headquarters was offered. One was in the building in which is located the naval radio station NPG, where many radiographic weather reports destined for the Weather Bureau are received. These, together with information intended specially for the flight project, would be instantly available to the naval meteorologists if headquarters were there. Another site was Crissy Field. Here the flight project was based; and as a result, contact with project officers and pilots would be most direct. The Weather Bureau office in San Francisco offered the third and finally selected choice, decision having been left to the naval aerologist of the San Diego Naval Air Station, who was in charge of meteorological preparations. He conducted all his operations from this office. By so doing full use was made of Weather Bureau facilities, and the necessity of preparing independent synoptic charts was obviated. Frequent consultation with the forecast officials there was also easy, and this worked to the mutual advantage of both the Navy and the Weather Bureau, as the latter was thereby in intimate touch with

[1]The naval radio station at San Francisco is designated by the call letters NPG.

the needs of the former, while the Navy meteorologists could draw on the special knowledge and experience of the Weather Bureau officials for advice on which to base their decisions.

Two special bulletins were issued by the Weather Bureau for the information of the flight project officials, one on the day of the flight and one on the day preceding. The following is the bulletin issued on August 30 and before the flight:

AUGUST 30, 1925.

Meteorological situation over the northeastern Pacific Ocean and the outlook for wind and weather over the route from San Francisco to the Hawaiian Islands.

The bulletin on the day of the flight reads as follows:

AUGUST 31, 1925.

Meteorological situation over the Pacific Ocean and the outlook for wind and weather over the flying route from San Francisco to the Hawaiian Islands.

Situation to-day.—The area of high barometer referred to in previous reports continues to dominate the wind and weather conditions over the ocean east of longitude 180°. Its center is in approximately latitude 40° north and longitude 150° west, where the barometer stands near 30.40 inches. A disturbance of marked intensity is over the Bering Sea and moving east-northeastward. Light northerly winds, velocity 8 to 12 miles an hour, with stratus clouds, but no fog, prevail as far west as longitude 135° west; beyond longitude 135° west to 145° west the winds are mostly

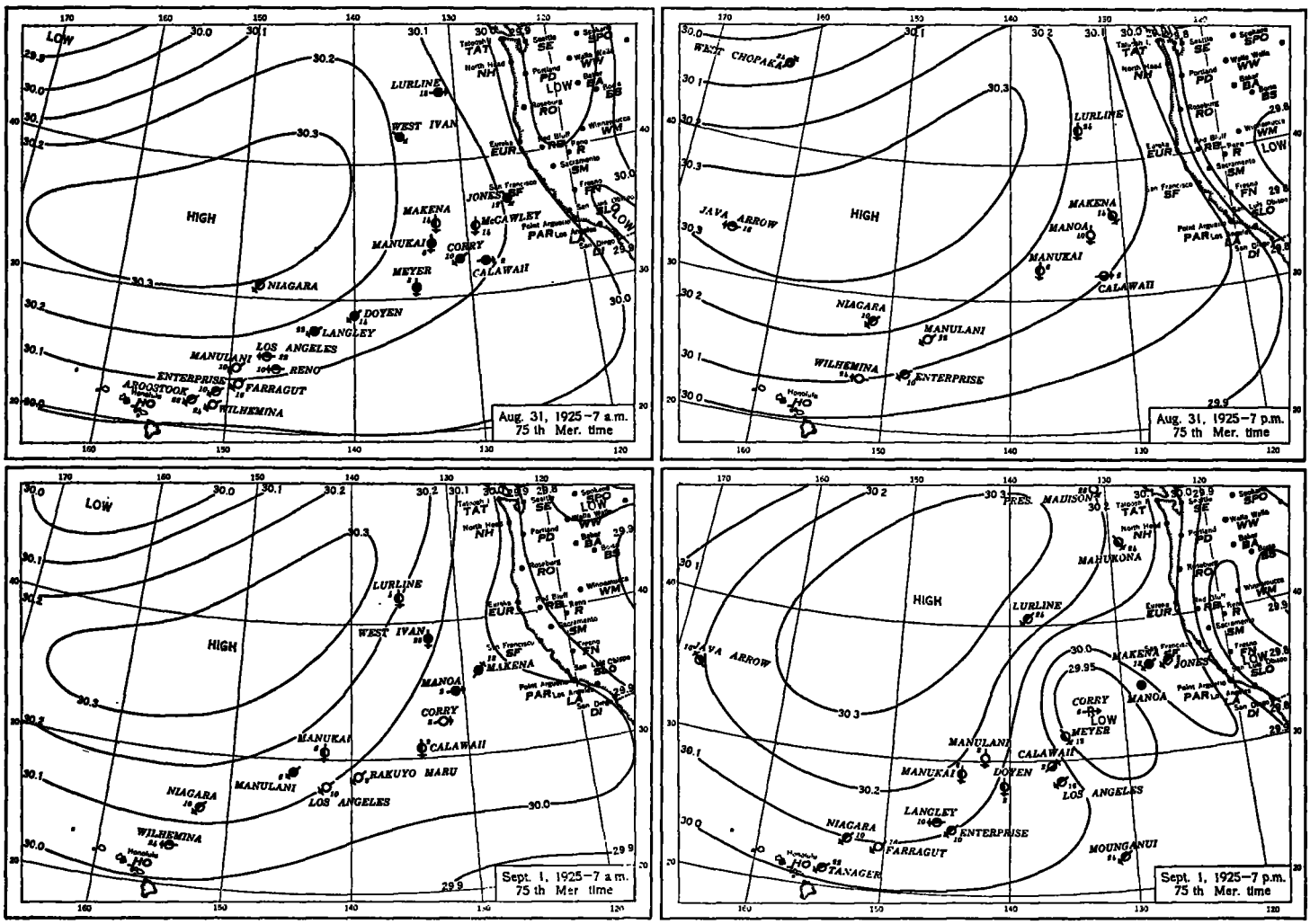

FIG. 2—Weather conditions along the route of the San Francisco-Hawaii flight, August 31 and September 1, 1925

Situation.—The barometer stands high generally over the ocean south of latitude 50°, with the center of maximum pressure in approximately latitude 40° and west longitude 145°, where the pressure is near 30.40 inches. Low barometric pressure prevails to the northward of latitude 50°, and a disturbance of considerable intensity has its center near Dutch Harbor, Unalaska, whence it will move eastward. The weather is overcast, with light northerly winds, not more than 10 miles an hour, from the California coast westward to longitude 130°; beyond 130° the winds are northeast, 10 to 18 miles an hour, and the sky partly overcast, as far as longitude 145°; beyond 145° to and including the vicinity of the Hawaiian Islands, the sky is partly overcast with strato-cumulus clouds and the winds are east, 15 to 20 miles an hour.

Outlook.—The indications are that the pressure situation as described under "Situation" will undergo little change within the next 36 hours, and that the wind and weather will be favorable along the route from San Francisco to the Hawaiian Islands for the start of the flight Monday.

northeast, 10 to 20 miles an hour, and the sky overcast with strato-cumulus clouds; beyond longitude 145° west to and including the vicinity of the Hawaiian Islands, the winds are east and northeast and from 15 to 24 miles an hour and the sky generally clear. No fog reported along entire route; ceiling 1,000 feet or above.

Outlook.—The indications point strongly to a continuance of the prevailing pressure situation and current wind and weather conditions along the flying route during the next 36 to 48 hours. *The conditions are exceptionally favorable for the start of the flight.*

The situation along the flying route approximated very closely what was predicted, a fact particularly gratifying to all concerned in view of the enforced descent of both planes in the open sea and the extraordinary hazard which would have resulted had the weather become stormy during or after the period of the flight. Lieutenant Snody was brought down by mechanical difficulties

when about 300 miles from San Francisco. He was promptly picked up. Commander Rodgers was less fortunate. When approaching the Hawaiian Islands, after some 1,800 miles of flight, his gas supply gave out and he was compelled to land. Although the plane was in communication by radio with the patrol ship *Aroostook* until nearly the moment of her descent, efforts to locate her were unavailing. All surface craft which the Navy could assemble in those waters engaged in the search. Nine days later, at 4 p. m., September 10, after hope of effecting a rescue had been practically abandoned, the plane and all her crew were picked up by the submarine *R–4*, 15 miles east of the island of Kauai.

During the interim between the time of the plane's disappearance and her discovery various theories were advanced to account for the failure to locate her. It was naturally assumed that she had foundered, and attempts were made to attribute the catastrophe to the prevalence of foul weather in the vicinity of the islands at the time she went down. In many cases newspaper accounts exploited this possibility with the tone of assurance, assuming that she was buffeted by wind and sea, and sank immediately. In fact, this impression seemed to become so widely current that the Weather Bureau issued to the press statements testifying to the nonexistence of abnormal weather conditions during the time the plane was in flight and for several days after she came down. The weather charts on which this contention was based are reproduced in Figure 2 to show the wind, weather, and pressure situation over the Pacific Ocean between the Pacific coast of North America and the one hundred and seventieth meridian, west longitude. They include the period from the morning of August 31 to the evening of September 1, the entire interval of flight. They are practically replicas, on small scale, so far as the situation at sea is concerned, of the synoptic charts for that period prepared in the San Francisco office of the Weather Bureau, on the basis of radiographic weather reports from ships in the North Pacific Ocean, the observations being made at 7 a. m. and 7 p. m., seventy-fifth meridian time. These observations do not, it will be observed, imply the existence of abnormal weather conditions in the area of the Hawaiian Islands at any time during the period.

The symbols employed are the usual ones to indicate wind direction and state of weather. An unfilled circle indicates clear weather at the time of observation, a half-filled circle partly cloudy weather, and a filled circle cloudy weather. Arrows fly in the direction in which the wind is reported as blowing. The velocity of the wind as estimated by the observer is given in miles per hour at the point of the arrow. Where no arrow is shown the weather is understood to be calm.

While the concluding chart of the series, that for the evening of September 1, indicates a moderate depression some distance off the southern California coast, conditions everywhere west of longitude 145° are of the type that might be expected to prevail there over the greater part of the summer. Cloudiness is neither extensive nor of an unusual character, while winds as regards both direction and force are normal.

The evening report from the U. S. S. *Langley* on September 1 incorporated the following additional data, obtained from pilot balloon observations, exhibiting the movement of the wind aloft:

Altitude (feet)	Wind direction	Velocity, miles per hour
Surface.	NE	10
1,000	NE	16
2,000	NE	13
3,000	NE	12
4,000	NE	12

The *Langley's* position, in approximately latitude 26° N., longitude 146° W., while not close to the point at which Commander Rodgers was forced down, was nevertheless not so remote as to render free-air data inapplicable, and her observations serve to confirm the inferences drawn from surface data throughout the area as to the nonexistence of any abnormal tendencies either local or widespread west of longitude 145°.

It is a pleasure to record the cordiality of cooperation between the Weather Bureau and the Navy Department in the transactions incident to the west coast-Hawaiian flight. The following letter to the official in charge at the San Francisco office of the Weather Bureau from Capt. Stanford E. Moses, United States Navy, commander, aircraft squadrons, Battle Fleet, who was designated to act as project commander for the flight, bears significant testimony thereto:

> I want to thank you and your assistants at the Weather Bureau for their kindness and splendid cooperation with us in connection with the west coast-Hawaiian seaplane flight.
>
> Your work was excellent and your long knowledge of weather conditions was of great help to us.

A FURTHER STUDY OF THE RELATION BETWEEN COVER CROPS AND ORCHARD TEMPERATURES

By FLOYD D. YOUNG

[Weather Bureau office, Los Angeles, Calif., September 29, 1925]

For a number of years many citrus growers in southern California have believed that the presence of a cover crop in an orchard lowers the temperature several degrees on a frosty night. As a result, the growing of winter cover crops has been abandoned in many citrus groves where this practice is quite necessary to maintain the fertility of the soil. Shortage of irrigation water prevents the growing of summer cover crops in most districts.

The Weather Bureau carried on experimental work at Pomona during the winter of 1921–22, to determine just what influence a cover crop has on the temperature on frosty nights. A complete report on this work was published in the MONTHLY WEATHER REVIEW.[1]

It was found that the air temperature was depressed only 0.1° F. at a height of 5 feet above the ground, and 1.0° F. at a height of 10 inches above the ground, due to the presence of a cover crop. Since there usually is little fruit near the ground, the temperature differences found should have little effect on the amount of damage to the fruit.

Observations made with unsheltered thermometers, at heights of 24 inches and 7 inches, respectively, showed that the minimum temperature was lowered 0.4° F. at the 24-inch elevation and 2.4° F. at the 7-inch elevation, due to the presence of the cover crop. Temporary temperature differences in the earlier part of the night as great as 8.7° F. at the 24-inch elevation, and 11.0° F. at the 7-inch elevation, were observed. These large differences

[1] Young, Floyd D.: Influence of Cover Crops on Orchard Temperatures. MONTHLY WEATHER REVIEW, October, 1922, 50 : 521–526.